

Fundamental Properties of POE Refrigeration Oils for Low GWP Refrigerants

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Compressors used in refrigeration and air conditioning systems, such as automotive air conditioners, are charged with a lubricating refrigeration oil. In compressors, refrigeration oil plays important roles, including lubrication of sliding parts and maintenance of sealing performance. Since refrigeration oils are used in the presence of refrigerants, they are required to have properties such as miscibility with refrigerants, thermochemical stability, electrical characteristics, and lubricity. In the refrigeration and air conditioning field, the transition to refrigerants with low global warming potential (GWP) is being promoted in order to reduce the impact of refrigerants on global warming. Hydrofluorocarbon (HFC) refrigerants, which have been widely used, have high GWP values and are subject to international phase-down measures. Under these circumstances, hydrofluoroolefin (HFO) refrigerants with low GWP have attracted attention as alternative candidates. In particular, 2,3,3,3-tetrafluoropropene (R1234yf), which is a type of HFO refrigerant, has become widely used in commercial products, and further demand is expected in the future. Meanwhile, stricter regulations on organic fluorine compounds are being considered, mainly in Europe, and natural refrigerants such as propane (R290), a fluorine-free hydrocarbon refrigerant with low GWP, are also attracting attention. Against this background, refrigerants used commercially are expected to become increasingly diversified, necessitating the investigation of refrigeration oils compatible with a wide range of refrigerants. Furthermore, as compressors are also being electrified along with the transition from internal combustion engine vehicles to electric vehicles, demand is increasing for ester-based refrigeration oils with excellent electrical characteristics. Therefore, in this study, the compatibility of polyol ester (POE), a synthetic oil, with R1234yf and R290 was evaluated.

In this study, an additive-free POE base oil (POE A) and a formulated POE oil containing an antioxidant, an acid scavenger, and an anti-wear additive (POE B) were used. Commercially, POE oils of various viscosity grades are used depending on the application. Here, a VG68 grade POE oil, as defined by the ISO viscosity classification (JIS K 2001-1993), was selected because it is used in a wide range of applications, including air conditioners.

Lubricity was evaluated using a block-on-ring test. In this evaluation, a Test Ring S-10 and Test Block H-30 manufactured by FALEX Corporation were used. The test was conducted under a load of 500 N, a sliding speed of 0.5 m/s, a test temperature of 50°C, and a test duration of 1 h, while the refrigerant pressure was adjusted so that the kinematic viscosity of the test oil under the refrigerant atmosphere was 13.5 mm²/s. The measured wear depths of the block specimens after the test are shown in Fig. 1. For POE A, the wear depth increased under the R290 atmosphere compared with that under the R1234yf atmosphere. In contrast, POE B exhibited reduced wear depth under both refrigerant atmospheres, confirming the lubricity improvement effect of the additives.

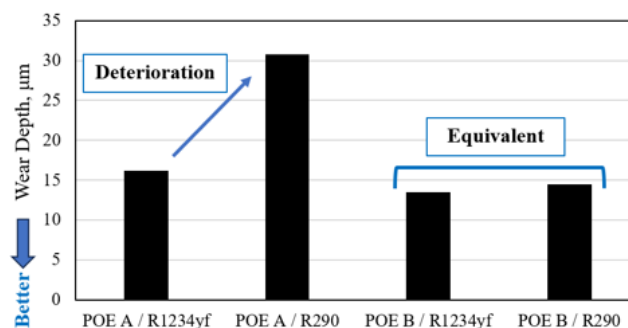


Fig. 1 Results of the Lubricity Test

Thermochemical stability was evaluated by sealing refrigeration oil with a water content of 1000 ppm, metal catalysts, and each refrigerant in a pressure vessel, followed by heating at 175°C for 336 h. The results are shown in Table 1. While POE A exhibited a slight increase in acid number under the R1234yf atmosphere, increases in acid number were suppressed for POE B under both R1234yf and R290 atmospheres.

Table 1 Results of the Thermochemical Stability Test

Sample		POE A		POE B	
		R1234yf	R290	R1234yf	R290
Acid Number After Stability Test	mgKOH/g	0.10	0.03	0.01	<0.01
Impurities	mg/100gOIL	1.1	0.4	0.4	0.7
ASTM Color	-	L0.5	L0.5	L0.5	L0.5

In this study, various properties of POE oils were evaluated under R1234yf and R290 atmospheres, low GWP refrigerants that have recently attracted attention. In particular, by incorporating appropriate additives into POE oils, excellent lubricity and thermochemical stability were demonstrated under R1234yf and R290 atmospheres. These results demonstrate that appropriately formulated POE oils have potential applicability to multiple refrigerants, an increasingly important property as refrigerants become more diversified.